

Claims

1. Method of evaluating a physical quantity associated with an interaction between a wave and an obstacle, in a region of three-dimensional space, in which:
 - a) a plurality of surface samples (dS_i), of which a part at least represents the surface of an obstacle receiving a main wave and emitting, in response, a secondary wave, is determined by meshing, and at least one source (S_i) emitting an elementary wave representing a contribution to the said secondary wave is allocated to each surface sample,
 - b) a matrix system is formed, comprising:
 - an invertible interaction matrix ($F(M)$), applied to a given region (M) of space and comprising a number of columns corresponding to a total number of sources,
 - a first column matrix, each coefficient (v_i) of which is associated with a source (S_i) and characterizes the elementary wave that it emits,
 - and a second column matrix, which is obtained by multiplication of the first column matrix by the interaction matrix and the coefficients of which are values of a physical quantity ($V(M)$) representative of the wave emitted by the set of sources in the said given region (M),
 - c) to estimate the coefficients of the first column matrix (v_i), chosen values of physical quantity ($V(P_i)$) are assigned to predetermined points (P_i), each associated with a surface sample (dS_i), the said chosen values ($V(P_i)$) being placed in the second column matrix, and this second column matrix is multiplied by the inverse of the interaction matrix applied to the said predetermined points (P_i),

- d) to evaluate the said physical quantity ($V(M)$) representing the wave emitted by the set of sources in a given region (M) of three-dimensional space, the interaction matrix is applied to the said given region (M) and this interaction matrix is multiplied by the first column matrix comprising the coefficients estimated in step c).
2. Method according to Claim 1, in which, to evaluate a physical quantity representative of an interaction between an element radiating a main wave and an obstacle receiving this main wave,
- in step a), a plurality of surface samples (dS'_i) together representing an active surface of the element radiating the main wave is furthermore determined, by meshing, and at least one source (S'_i) emitting an elementary wave representing a contribution to the said main wave is allocated to each sample of the active surface,
 - steps b), c) and d) are furthermore applied to the samples of the active surface, and
 - the said physical quantity ($V(M)$) representing the interaction between the radiating element and the obstacle in a given region (M) of three-dimensional space is evaluated by taking account of the contribution, in the said given region (M), of the main wave emitted by the set of sources of the active surface and the contribution of the secondary wave emitted by the set of sources of the surface of the obstacles.
3. Method according to one of Claims 1 and 2, in which each coefficient of the interaction matrix, applied to a given region of space, is representative of an interaction between a source and the said given region and the value of each

coefficient is dependent on a distance between a source and the said given region.

4. Method according to one of Claims 1 to 3, in which
5 the interaction matrix applied, in step c), to the said predetermined points (P_i) comprises a number of rows corresponding to a total number of predetermined points (P_i).
- 10 5. Method according to one of Claims 1 to 4, in which the physical quantity to be evaluated is a scalar quantity ($V(P_i)$) and, in step a), a single source is allocated to each surface sample.
- 15 6. Method according to Claim 5, in which the interaction matrix ($F(M)$) applied, in step d), to a region of space (M) comprises a row.
- 20 7. Method according to one of Claims 5 and 6, in which each predetermined point (P_i) associated with a surface sample (dS_i) corresponds to a point of contact between this surface sample (dS_i) and a hemisphere whose surface is equal to the surface of this surface sample, and whose centre
25 corresponds to a position of the source (S_i) which is allocated to this surface sample.
8. Method according to one of Claims 5 to 7, in which:
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 - the main wave is an electric wave,
 - the coefficients of the first column matrix are values of electric charge that are each associated with a source, and
 - the coefficients of the second column matrix are
35 values of electric potential.
9. Method according to one of Claims 5 to 7, in which:
 - the main wave is a magnetic wave,

- the coefficients of the first column matrix are values of magnetic flux that are each associated with a source, and
 - the coefficients of the second column matrix are values of magnetic potential.
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10. Method according to one of Claims 5 to 7, in which,
- the main wave is a sound wave,
 - the coefficients of the first column matrix are values of speed of sound that are each associated with a source, and
 - the coefficients of the second column matrix are values of acoustic pressure.
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11. Method according to one of Claims 1 to 4, in which the physical quantity to be evaluated is a vector quantity ($\underline{V}(P_i)$) expressed by its three coordinates in three-dimensional space, and three sources (SA_i , SB_i , SC_i) are allocated, in step a), to each surface sample (dSi).
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12. Method according to Claim 11, in which the interaction matrix ($F_y(M)$) applied, in step d), to a region of space (M) comprises a row for each space coordinate (X , Y , Z).
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13. Method according to one of Claims 11 and 12, in which:
- the three sources allocated to each surface sample are substantially in one and the same plane, and
 - each predetermined point (P_i) associated with a surface sample (dSi) corresponds to a point of contact between this sample and a hemisphere whose surface is equal to the surface of this sample, and whose centre corresponds to the position of a barycentre of the three sources.
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14. Method according to Claim 13, in which the three sources of one and the same surface sample form substantially an equilateral triangle, and the triangles of the surface samples are oriented substantially randomly with respect to one another.
15. Method according to one of Claims 11 to 14, in which:
- the main wave is an electric wave,
 - the coefficients of the first column matrix are values of electric charge that are each associated with a source, and
 - the coefficients of the second column matrix are values of coordinates of an electric field.
16. Method according to one of Claims 11 to 14, in which:
- the main wave is a magnetic wave,
 - the coefficients of the first column matrix are values of magnetic flux that are each associated with a source, and
 - the coefficients of the second column matrix are values of coordinates of a magnetic field.
17. Method according to one of Claims 11 to 14, in which:
- the main wave is a sound wave,
 - the coefficients of the first column matrix are values of speed of sound that are each associated with a source, and
 - the coefficients of the second column matrix are values of coordinates of an acoustic velocity.
18. Method according to one of the preceding claims, in which, to estimate the contribution of the secondary wave in the said given region in step d), the said values of physical quantity ($V(P_i)$) chosen in step c) are dependent on a predetermined

coefficient of reflection and/or of transmission of the main wave by each surface sample of the obstacle.

- 5 19. Method according to Claim 18, taken in combination with one of Claims 6 and 12, in which the secondary wave corresponds to a reflection of the main wave on the obstacle and the hemisphere is oriented outwards from the obstacle.
- 10 20. Method according to Claim 18, taken in combination with one of Claims 6 and 12, in which the secondary wave corresponds to a transmission of the main wave in the obstacle and the hemisphere is oriented inwards into the obstacle.
- 15 21. Method according to one of Claims 19 and 20, in which, in step c), the values (v'_i) associated with the sources (S'_i) of the radiating element (ER) are determined and at least the following are formulated:
- 20 - a first interaction matrix ($F(P)$) representing the contribution of the sources of the obstacle to the predetermined points of the surface of the obstacle (P_i),
- 25 - a second interaction matrix ($F'(P)$) representing the contribution of the sources of the radiating element to the predetermined points of the surface of the obstacle (P_i),
- 30 - a reflection (R) or transmission (T) matrix, whose coefficients represent coefficients of reflection or of transmission at each predetermined point (P_i) of the obstacle, to determine the values of the sources of the obstacle (v_i) as a function of the values of the sources of the radiating element (v'_i) and of a multiplication of the first and second interaction matrices and of the reflection or transmission matrix.
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22. Method according to Claim 21, in which, in step c), the values (v'_i) associated with the sources (S'_i) of the radiating element (ER) are determined by taking account of the reception of the secondary wave by the radiating element (ER) and by furthermore formulating:
- a third interaction matrix ($F(P')$) representing the contribution of the sources of the obstacle to the predetermined points of the surface of the radiating element (P'_i),
 - and a fourth interaction matrix ($F'(P')$) representing the contribution of the sources of the radiating element to the predetermined points of the surface of the radiating element (P'_i).
23. Method according to one of Claims 19 to 22, in which the surface of the obstacle corresponds to an interface between two distinct media of a heterostructure.
24. Method according to one of the preceding claims, in which the main wave is a sound wave and the coefficients of the interaction matrix are each dependent on an angle of incidence of an elementary wave emanating from a source in the said given region (M).
25. Method according to one of Claims 7 and 13, in which, for each surface sample, the value is tested of a scalar product of:
- a first vector (\vec{r}) normal to the surface sample and directed towards the apex (P) of the hemisphere (Fig. 7A), and
 - a second vector (\overline{SM}) drawn between a source (S) associated with this hemisphere and the said given region (M),
- while distinguishing:

- the case where this scalar product is less than a predetermined threshold and the contribution of this source is not taken into account, and
 - 5 - the case where this scalar product is greater than a predetermined threshold and the contribution of this source is actually taken into account.
- 10 26. Method according to one of the preceding claims, in which the main wave is a sound wave and, in step a), a total number of surface samples (dS_i) is chosen substantially as a function of a wavelength of the sound wave so as to satisfy the
- 15 Rayleigh criterion.
27. Method according to one of the preceding claims, in which a plurality of values of the physical quantity estimated in step d), which are obtained
- 20 for a plurality of regions of space, are compared so as to select a candidate region for the placement of a radiating element intended to interact with the obstacle.
- 25 28. Method according to one of Claims 2 to 27, in which the radiating element is a sensor, for nondestructive testing, intended for analysing an object forming an obstacle of the main wave.
- 30 29. Computer program product, stored in a central unit memory or on a removable support able to cooperate with a reader of this central unit, characterized in that it comprises instructions for implementing the method according to one of the preceding
- 35 claims.